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Black Sigatoka severity and growth performance of two plantain cultivars in Omu-Aran, Southern Guinea Savannah of Nigeria

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Abstract

Black Sigatoka is the most serious biotic threat to plantain production in sub-Saharan Africa. The photosynthetic function of plantains at the vegetative growth stage ultimately determine the yield and this makes it absolutely necessary to routinely monitor black Sigatoka severity. The current study investigated the severity of black Sigatoka disease on two plantain cultivars and their growth performance. Suckers of False Horn 'Agbagba' and PITA 25 plantain cultivars were planted in an open field at a spacing of 3m between rows and 2m within rows. A plot size of 90m x 50m was used for the study. The experiment was laid in a randomized complete block design (RCBD) with three replicates. Disease development was observed under natural infection. The parameters investigated include disease severity, plant height, pseudostem girth and number of functional leaves. Black Sigatoka disease increased with plant age in the two cultivars. The lowest black Sigatoka severity (0.2) was recorded on PITA 25 at 8 weeks after planting (WAP). The number of functional leaves on the two cultivars was also affected by the disease, decreasing generally with plant age on False Horn 'Agbagba' while increasing with plant age on PITA 25. The highest number of functional leaves (14.6) was observed on PITA 25 plantains at 18 WAP while the least (4.3) was noticed on False Horn 'Agbagba' at 14 WAP. Hybrid plantains are more resistant to black Sigatoka disease and are therefore recommended as a replacement for the local varieties that are highly susceptible, besides being poor yielding.

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Introduction

Banana and plantain (*Musa* spp.) are cultivated in over 130 countries worldwide covering approximately 10 million hectares, with an annual production of 139 million tons (FAOSTAT, 2014). They rank 8th in world production of staple food crops (Tripathi *et al*., 2014) and are often produced by small-scale farmers in tropical and subtropical regions mainly for home consumption and also for sale in local and regional markets rather than for international trade (Tripathi *et al*., 2015). Plantain is a major staple in West and Central Africa (Norgrove and Hauser, 2014), with Southern Nigeria identified as a key area where production needs to be given priority in order to ensure future world food security (Godfray *et al*., 2014; West *et al*., 2014).

Musa spp. is excellent source of carbohydrate, vitamins and minerals, particularly iron, magnesium and calcium. In Nigeria, plantain is the third most important starchy staple grown after cassava and yam (Norgrove and Hauser, 2014). Nigeria is one of the largest plantain producing countries in the world, with an annual estimate of 2.4 million metric tons (FAO, 2006). The yield of plantain has reduced significantly over the years, resulting in a threat to food security and the livelihood of millions of subsistence farmers and their families in regions where the crop is grown. The low yield has been attributed to soil degradation, poor crop management, drought, and pests and diseases http://www.iita.org/banana-and-plantain.

Pests and diseases have been identified as one of the major constraints to banana and plantain production (Jones, 2009). Black Sigatoka or black leaf streak (BLS) disease caused by the fungus, *Mycosphaerella fijiensis*, is considered the most serious biotic threat to plantain and banana production in sub-Saharan Africa (Orluchukwu and Ogburia, 2014). The disease occurs mostly in hot and humid climates, producing dark spots on leaves and causes the fruits to ripen prematurely. The fungus rapidly destroys leaf tissues and as a result, photosynthesis is reduced which ultimately affect plant growth and productivity. Yield losses of 20-50% have been attributed to this disease (Seydou *et al*., 2017) and may reach 100% as from the second crop cycle (Chillet *et al*., 2009; Zandjanakou *et al*., 2013).

The effect of black Sigatoka disease on the growth performance of plantain need to be routinely monitored, particularly, at the vegetative growth stage of the crop in order to maintain the photosynthetic functions of the plant, as this ultimately determine the yield of the crop. The current study therefore investigated the severity of black Sigatoka disease on two plantain cultivars and their growth performance under natural infection.

Materials and methods

Study site

The experiment was carried out at the Horticultural site of Landmark University, Omu-Aran, Kwara State, Nigeria. Omu-Aran lies between latitude 8°8' N and longitude 5°6' E of the equator. Annual rainfall ranges between 600 and 1,500 mm with a distinct dry season from December to March. The mean annual temperature varies from 28°C to 34°C. The humidity ranges between 50% in the dry season to about 85% during wet season.

Experimental design and treatments

The experiment was laid in a randomized complete block design (RCBD) with three replicates. A plot size of 90m x 50m was used for the study. Suckers of False Horn 'Agbagba' and PITA 25 plantain cultivars obtained from the National Horticultural Research Institute, (NIHORT), Jericho, Idi-ishin, Ibadan, Oyo state, Nigeria were planted in an open field at a spacing of 3m between rows and 2m within rows. Cultivar Agbagba, otherwise referred to as 'AAB False Horn plantain' is a popular African landrace widely accepted and commonly cultivated by farmers, in spite of availability of several improved varieties. The cultivar is the most preferred and most common plantain landrace in Nigeria (Ortiz and Tenkouano 2011) while PITA 25 is an improved variety that is yet to be widely cultivated in the agroecological zone where the current study was carried out.

All crop management practices were carried out, with the exception of disease control. The plants were examined and evaluated before flowering during rainy season when conditions were favourable for plant growth and disease development. Disease development was observed under natural infection on the field.

Data collection and analysis

Data were collected on disease severity, plant height, pseudostem height and number of functional leaves. Disease severity assessment was carried out on a standard scale of 0-6, according to Stover and Dickson (1970), where;

0= no symptoms

1= less than 1% (only streaks up to 10 spots) leaf area with symptoms

2= 1 to 5% leaf area with symptoms

3= 6 to 15% leaf area with symptoms

4= 16 to 33% leaf area with symptoms

5= 34 to 50% leaf area with symptoms, and

6= 51 to 100% leaf area with symptoms

Data collected was subjected to analysis of variance (ANOVA) using the statistical analysis system (SAS) (2000) and treatment means were separated using LSD at 5% probability level.

Results

Mycosphaerella fijiensis confirmation

Randomly selected symptomatic leaf samples were collected from the two cultivars in the experimental plot. Single ascospores were recovered using the discharge technique, transferred to PDA, and later sub-cultured in PDA broth for mycelium production. DNA was extracted from lyophilized and ground mycelium using a Fast DNA Spin Kit (MP Biomedicals, Solon, OH) following the manufacturer's protocols. Isolates were then amplified with the polymerase chain reaction and Internal Transcribed Spacer (ITS) primers that are specific for *M. fijiensis*. Amplicons were separated and visualized via electrophoresis in a 1.5% agarose gel.

Table 1. Severity of black Sigatoka disease on False Horn 'Agbagba' and PITA 25 plantain cultivars.

Cultivar	Disease severity					
	8 WAP	10 WAP	12 WAP	14 WAP	16 WAP	18 WAP
False Horn	0.5	2.1	2.8	3.3	4.7	5.6
PITA 25	0.2	0.3	1.1	1.6	1.8	2.3
$LSD_{0.05}$	0.4	1.7	1.5	1.8	2.1	2.6

WAP= Weeks after planting

Values are means of three replicates.

Severity of black Sigatoka on False Horn 'Agbagba' and PITA 25 plantain cultivars

Significant differences were observed in disease severity between the False Horn 'Agbagba' and PITA 25 plantain cultivars (Table 1).

Disease severity increased with plant age. The lowest black Sigatoka severity (0.2) was recorded on PITA 25 at 8 weeks after planting (WAP) while the highest (5.6) was observed on False Horn 'Agbagba' at 18 WAP.

Effect of black Sigatoka on plant height, pseudostem girth and number of functional leaves of False Horn 'Agbagba' and PITA 25 plantain cultivars

Table 2 shows the effect of black Sigatoka disease on plant height, pseudostem girth and number of functional leaves of False Horn 'Agbagba' and PITA 25 plantain cultivars. At 10, 12, 14, 16 and 18WAP, PITA 25 had significantly ($P \leq 0.05$) higher heights than False Horn 'Agbagba'. The tallest plants (203.9cm) were observed in PITA 25 cultivar at 18WAP.

Black Sigatoka disease did not significantly ($P \leq 0.05$) influence the pseudostem girth of the plantain cultivars. However, numerically higher pseudostem girths were recorded in PITA 25 plantain at the different weeks of assessment.

At 12, 14, 16 and 18 WAP, PITA 25 had significantly (P≤0.05) higher number of functional leaves at the different weeks of assessment.

The highest number of functional leaves (14.6) was observed on PITA 25 plantains at 18 WAP while the least (4.3) was noticed on False Horn 'Agbagba' at 14 WAP.

Table 2. Effect of black Sigatoka disease on plant height, pseudostem girth and number of functional leaves of False Horn 'Agbagba' and PITA 25 plantain cultivars.

Cultivar	Plant height (cm)						Pseudostem girth (cm)						Number of functional leaves					
	Weeks After Planting																	
	8	10	12	14	16	18	8	10	12	14	16	18	8	10	12	14	16	18
False Horn	103.6	106.2	118.3	120.4	139.1	150.7	15.2	16.3	17.4	21.4	29.6	38.7	4.5	4.8	4.5	4.3	4.4	3.8
PITA 25	110.3	128.3	142.5	154.1	186.5	203.9	14.7	17.7	20.3	24.5	33.1	45.6	4.3	6.0	8.8	10.3	12.5	14.6
$LSD_{0.05}$	8.4	11.5	18.2	25.7.1	36.6	42.8	1.3	2.6	3.5	4.3	11.8	16.6	0.7	1.6	2.1	4.1	4.6	6.7

Values are means of three replicates.

Discussion

The present study investigated the severity of black Sigatoka disease on a popular landrace of plantain (False Horn 'Agbagba') and an improved variety (PITA 25). The research work also examined the growth response of the two plantain cultivars to black Sigatoka leaf spot pathogen under natural infection conditions. The parameters investigated include disease severity, plant height, pseudostem girth and number of functional leaves.

Black Sigatoka severity: Black Sigatoka disease increased with plant age in the two cultivars. This observation is in consonance with the findings of Oluma *et al.* (2004) that reported a positive correlation between black Sigatoka severity and plant age.

Number of functional leaves: The number of functional leaves on the two cultivars was also affected by the disease, decreasing generally with plant age on False Horn 'Agbagba' while increasing with plant age on PITA 25. The higher the number of functional leaves on the plants, the higher the conversion of photosynthetic assimilates for dry matter production (Ndukwe *et al.*, 2009). As such, increased percentage of non-spotted leaves will lead to an increase in the yield components and yield of plantain. According to Orjeda (1998), banana plants require more than 70% of active foliage and a minimum of eight functional leaves for proper development of the fruits.

Plantains are severely defoliated by black Sigatoka disease and a decrease in functional leaf area results in yield loss through a reduction in the number of fruits per bunch and lower fruit weight (Mobambo *et al.* 1993).

Several improved plantain and banana varieties with good agronomic traits, yield and better resistance to black Sigatoka disease have been developed through breeding and selection program. Improved varieties of plantains include PITA 21, PITA 23, FHIA 25, PITA 14, PITA 17, PITA 3 and FHIA 23 (Njukwe *et al.*, 2008). These varieties exhibit higher levels of resistance to black leaf streak (BLS), have shorter growth cycles and produces higher bunch yield in comparison to the landraces. Furthermore, when grown in mixture with landraces, the hybrids mitigate the intra-field propagation of *M. fijiensis* between susceptible plants, thereby, enhancing the performance of the landraces under natural BLS infection. This constitutes an attractive scheme for deployment of the improved hybrids through on-farm participatory evaluation in plantain growing areas across all ecological zones in Nigeria. Ortiz and Tenkouano (2011) also advocated a strategy of mixing an improved Sigatoka-tolerant hybrid with susceptible landrace by planting in a chequerboard configuration to minimise losses to black Sigatoka, maintain cultivar diversity and improve overall yield.

Conclusion

The effect of black Sigatoka disease on the growth performance of plantain need to be routinely monitored, particularly, at the vegetative growth stage of the crop in order to maintain the photosynthetic functions of the plant, as this ultimately determine the yield of the crop based on other yield parameters such as fruit size, number of bunches, number of fingers per bunch, bunch weight etc. Generally, hybrid plantains are more resistant to black leaf streak and are therefore recommended as a replacement for the local varieties that are highly susceptible, besides being poor yielding.

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